Ecological environment analysis of *Abies holophylla* plantations under different cutting systems[1)]

Chen Hongji (陈宏吉)
Liaoning Academy of Forest Science, Shenyang 110032, P. R. China

Abstract Different types of plantations were observed in Baishilazi National Nature Reserve, Liaoning Province, for 34 a. The environmental quality of *Abies holophylla* plantations was analyzed under different cutting systems. Analysis factors included soil erosion rate, humification degree of litters, and water hold capacity. The surface soil loss of clear cutting area was 19 000 $t \cdot km^{-2} \cdot a^{-1}$ more than that of selective cutting area. The content of soil organic matter in board-leaved--*Abies holophylla* forest was 4.62% more than that in pure stand, and the water hold capacity of the mixed forest was 1.43 time of that of pure stand. The mixed forest of board-leaved--*Abies holophylla* by selective cutting can upgrade the ecological environment quality.
Key words: Cutting systems, *Abies holophylla* plantation, Ecological environment

The *Abies holophylla* plantations were fostered not only for high economic profit, but also for the good of a sound ecological environment. So, the environment assessment was stressed during afforestation and management to built theory base for ecological engineering.

Soil erosion rate

Three types of stands, Japanese xylosma forest, stands of selective cutting, and stands of clear cutting, were investigated. Gradient, soil thickness, vegetation and soil erosion were surveyed (Table 1).

Table 1. Soil erosion rate under three types of stands

Stand type	Gradient /(°)	Soil thickness /cm	Vegetation coverage (%)	Soil loss /$t \cdot km^{-2} \cdot a^{-1}$	Erosive rate /$mm \cdot a^{-1}$
Intact stand	23~30	40	70~80	100	0.10
(Type I)	30~40	20~30		410	0.40
Selective cutting	20	30~40	30~50	2 600	2.60
(Type II)	30	30~35		3 500	3.50
Clear cutting	<10	45	10	2 700	2.70
(Type III)	26	45		21 620	21.6
	45	35		27 640	27.6

One stand of type III with gradient of 45° and vegetation coverage of 10% has the highest soil erosion rate (27.6 $mm \cdot a^{-1}$), which was 6.5 times of type II and 26~27 times of type I respectively. This means that forest under clear cutting would have soil loss of 19 363 $t \cdot km^{-2} \cdot a^{-1}$ more than forest under selective cutting, which equals to a loss of 6 hm^2 forest land with a surface soil of 30 cm. According to "FAO forest land assessment": soil loss in forest land should be less than 5 000 $t \cdot km^{-2} \cdot a^{-1}$, we can reach the conclusion that in Baishilazi mountainous region of Kuandian county, selective cutting is a suitable system for preventing soil erosion. In the area with a slope of <10°, clear cutting is good, while in the area with a slope of 10~15°, clear cutting is permissible. The selective cutting, however, is proper to the slope area of larger than 15°. In slope area of 45° and boulder land clear cutting is forbidden and light selective cutting is recommended.

Humification of litter and soil fertility

Amount of litter and its humification degree were surveyed in three types of stands: broad-leaved--*Abies holophylla* mixed forest (selective cutting plot No.9), mixed forest of *Abies holophylla* and *Larix japonica* (clear cutting plot No.44), and pure forest of *Abies holophylla* (clear-cutting plot No.45).

The broad-leaved--*Abies holophylla* forest has large amount of litter and a high humification rate. The thickness of litter in this type of mixed forest is 2 times as much as that of mixed forest of *Abies holophylla* and *Larix japonica* and 1.6 times as much as that of pure forest. Meanwhile, the depth of humus-layer in plot No.9 is 3.5 times of that in plot No.44 and 5 times of that in plot No. 45. Organic matter in soil

[1)] This paper is a part of a key project from Liaoning Science Committee.
Received: 1999-05-13
Responsible editor: Zhu Hong

under different environment also varies remarkably. The content of organic matter of soil in three types of forest is 7.77%, 3.30%, and 3.15% respectively (Table 2), with a maximum in the broad-leaved--*Abies holophylla* forest.

Table 2. Humification of litters and soil fertility in three types of forests

Forest type (plot)	Litter thick-ness /cm	Humus thick-ness /cm	Organic mater (%)	Total N (%)	Total P (%)
No. 9	4.0	3.5	7.77	0.379 9	0.202 0
No. 44	2.0	1.0	3.30	0.167 3	0.151 2
No. 45	2.5	0.7	3.15	0.220 4	0.162 5

Water conservation

In the three types of forest mentioned above, water-holding capacity of litter and soil was measured and analyzed.

Broad-leaved--*Abies holophylla* forest has much more litter than mixed forest of *Abies holophylla* and *larix japonica* and pure forest, but the water content in pure forest is the highest among the three types of forests. The reason for that might be due to a good permeability of litter.

Through analyzing the data above, we know that the non-capillary porosity is related with water capacity and moisture content, namely the water conservation capacity of the forest. The non-capillary porosity is determined by soil structure and vegetation coverage. Broad-leaved--*Abies holophylla* forest has a high non-capillary porosity of soil, because of its proper community structure, high organic matter in the soil, and large amount of roots. In the other two forest types, the index is relatively lower. Non-capillary porosity of Broad-leaved--*Abies holophylla* forest is 1.28 and 1.49 times of that of the other two forests. And its land water capacity is 1.26, 1.43 times of other two forests respectively. The function of water conservation by forest is due to soil water hold capacity (static function) and soil permeability (dynamic function), which is both determined by non-capillary porosity of forest soil (Table 3, 4). However, soil permeability is more important for the soil in holding water continuously to realize the water conservation function. Reportedly, water conservation capacity of coniferous and hard wood mixed forest is 7 800~19 800 $t \cdot km^{-2} \cdot a^{-1}$, which is 1.3~3.3 times of that of pure coniferous forest.

Table 3. Water holding capacity of litter in three types of forests

Forest type (plot)	Dry weight of litter /t • hm^{-2}	Water capacity /t • hm^{-2}	Water capacity /mm	Water capacity ratio (%)
No. 9	35.0	70.00	7.0	200.0
No. 44	28.8	81.00	8.1	281.3
No. 45	32.9	105.75	10.6	321.4

Note: No. 9--Broad-leaved--*Abies holophylla* forest; No.44--mixed forest of *Abies holophylla* and *larix japonica;* No. 45-- pure stand of *Abies holophylla*

Table 4. Maximum static water capacity of three types of forest land

Forest type (plot)	Soil thick-ness /cm	Moisture content (%)	Non-capillary porosity (%)	Water capacity					
				Soil /t • hm^{-2}	Soil /mm	Litter /t • hm^{-2}	Litter /mm	Land /t • hm^{-2}	Land /mm
No. 9	40	32.65	26.62	2 130	213.0	70	7.0	2 200	220.0
No. 44	47	18.60	20.79	1 663	166.3	81	8.1	1 744	174.4
No. 45	47	20.55	17.88	1 430	143.0	105	10.5	1 535	153.5

Conclusions

It's very important to take account in water conservation for transforming secondary forest in eastern Liaoning mountainous area. In the area with a slope of <10°, clear cutting is good, while in the area with a slope of 10~15°, clear cutting is permissible. The selective cutting, however, is proper to the slope area larger than 15°. In slope area of 45° and boulder land clear cutting is forbidden and light selective cutting is recommended.

Planting seedling of *Abies holophylla* under the crown after selective cutting is a useful way to transform secondary forest. This technique is not only good for structure of mixed forest, but also bringing multiple profits, which should be recommended, in forestry practice.

References

Chen Hongji. 1993. On issue and strategy of land stonification in eastern Liaoning. Journal of Liaoning University, **4**

Florish Lodas, M.A. 1984. Assessment on forestland, FAO, Rome

Shun Baolin. 1998. Analysis of soil erosion in mountainous region of eastern Liaoning, Scientific information of water conservation, **3**

Zhao Kang. 1997. On control of soil erosion caused by cutting trees. Journal of water conservation, **5**